



## 2017 IEEE GRSS STRATUS Workshop

# Systems and Technologies for Remote Sensing Applications Through Unmanned Aerial Systems

19-20 October 2017

Louise Slaughter Hall  
Rochester Institute of Technology  
Rochester, New York, USA





## STRATUS 2017 Agenda

*Thursday, October 19, 2017*  
**Room 1630 Louise Slaughter Hall**

<b>Time</b>	<b>Tutorial</b>	<b>Speaker</b>
0830-0900	Registration/Breakfast	
0900-1200	Introduction to UAV Radiometry and Reflectance	Chris Durell, Labsphere
1200-1300	Lunch	
1300-1600	UAS Focused Photogrammetry / Mapping with Pix4D	Angad Singh Pix4D

*Friday, October 20, 2017*  
**Room 2240-2210, Louise Slaughter Hall**

<b>Time</b>	<b>Topic</b>	<b>Speaker</b>
0800-0830	<b>Registration/Breakfast</b>	
0830-0900	Welcome by STRATUS Chair and RIT Chester F. Carlson Center for Imaging Science	Emmett Ientilucci, RIT David Messinger, RIT
0900-0930	<b>Keynote:</b> The Use of Drones in Commercial Property Inspection	Charles Mondello, Property Drone Consortium
0930-1000	<b>Keynote:</b> Venture Creations and UAS Entrepreneurship	Richard Notargiacomo, RIT Venture Creations
1000-1020	<b>Coffee Break</b>	
1020-1040	UAS Operations Within Controlled Airspace	Brian Blazey, FAA
1040-1100	The Role of Flight Standards District Offices in UAS Safety	Robert Lacourse, FAA
1100-1120	NASA UAS Traffic Management (UTM) for Wildland Fire Air Domain Awareness	Ed Freeborn, Unmanned Experts
1120-1140	MX1: A New Multi-modal UAS Payload System with High Accuracy GPS and IMU	Timothy Bauch, RIT
1140-1200	USGS National UAS Project Office: Progress on Radiometric Calibration of UAS Imagery	Kelsey Mason, USGS
1200-1400	<b>Lunch and Networking</b>	
1400-1420	Small Unmanned Aerial Systems (sUAS) in Support of Advancements in Remote Sensing Data Quality	Katie Corcoran, ORNL
1420-1440	A Novel Calibration Technique for Images Captured by Unmanned Aerial Systems (UAS)	Baabak Mamaghani, RIT
1440-1500	Drone-based Sensing for solid Waste Facilities	Brent Bartlett, BeamIO
1500-1520	UAS in Secondary Education	Edward Levine, Syracuse City School District
1520-1540	<b>Coffee Break</b>	
1540-1600	Quadrotor Controller Development via Model Based Design	Daniel Kaputa, RIT
1600-1620	Microsystems Technology Inertial Sensors for Unmanned Aerial Vehicles	Liam Herlihy, RIT
1620-1640	Closing Remarks	Emmett Ientilucci, RIT



## Welcome from Workshop Chair

On behalf of the organizing committee, we would like to welcome everyone to the 2<sup>nd</sup> workshop on Systems and Technologies for Remote Sensing Applications Through Unmanned Aerial Systems or simply STRATUS 2017. The two-day workshop is being held in Rochester, New York, on October 19-20, 2017 at the Rochester Institute of Technology (RIT) home to some 19,000 students.

Last year's workshop was such an overwhelming success, we decided to move forward with an expanded version in 2017. This second iteration includes a full day of tutorials (on Thursday, Oct., 19<sup>th</sup>) given by Labsphere (on UAS Radiometry, Reflectance, and Calibration) and Pix4D (on UAS photogrammetry and mapping). Both the workshop itself and the tutorial sessions reached full seating capacity. In addition, we decided to make the lunch break longer so as to allow time for networking between speakers, companies, and students. For Friday, Oct. 20<sup>th</sup>, we assembled a total 12 unique talks and 2 keynote presentations. The talks range from hardware development and applications, to FAA regulation, to UAV's in secondary education while the keynote speakers will touch upon the uses of drones in commercial property inspection as well as strategies for UAS entrepreneurship.

The 2017 workshop was made possible, in part, by an IEEE Geoscience and Remote Sensing Society (GRSS) local chapter award. This allowed us to keep registration fees low while waiving said fees for students. The workshop also received the technical co-sponsorship of the IEEE GRSS enabling us to host the event on the IEEE GRSS website and advertise in the GRSS Magazine.

In general, the aim of this workshop is to facilitate interaction between academic researchers, industry researchers and students working in the field of remote sensing utilizing unmanned aerial systems. Since this is an emerging field, the goal of the workshop is not to *define* technical requirements, standards or legal policy, but rather to illustrate the specific connection between remote sensing and unmanned aerial platforms at both the commercial and academic levels. We aim to bring together academics, industry representatives, and domain specialists to share perspectives on this rapidly evolving topic.

We believe this program will promote the dissemination of research results and technical advances in this new emerging field of unmanned aerial systems. We hope you enjoy the tutorials and workshop and look forward to your participation!

Sincerely,



Dr. Emmett Lentilucci  
*STRATUS 2017 Workshop General Chair*



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<https://www.labsphere.com>

## **Tutorial 1: Introduction to UAV Radiometry and Reflectance**

*Chris Durell, Labsphere, Inc.*

This 3-hour tutorial will provide the attendee with an overview of optical radiometry. This introduction to radiometry will provide fundamental information about what radiometric units to use, how to use them, and how to perform the proper measurements to record specific radiometric quantities. The use of blackbodies and a standard sources will be discussed for calibration. The use of radiometry and calibration as applied to UAS applications, specifically, how to apply radiometric units to field applications in UAS space including visible, multispectral, LiDAR, SWIR and thermal cameras and sensor payloads will be discussed.

Topics will include

- 1) reflectance-based techniques
- 2) sources, visible to thermal, and
- 3) image-quality tests



**Instructor:** Chris Durell, Director of Business Development, Remote Sensing.

Chris graduated from Cornell University with an BSEE in 1993 and finished his MBA at Franklin Pierce College in 2003. Chris was the VP of Sales for both Labsphere and SphereOptics and has lead efforts to design optical, light measurement and remote sensing systems, products and technology for over 21 years. He is a member of SPIE, IES, ASTM, CIE, CORM, ICDM and is a participant in CEOS/IVOS, QA4EO, IEEE and other remote sensing groups. He has several patents and has published papers in many applications of light metrology and remote sensing.



<https://pix4d.com>

## **Tutorial 2: UAS Focused Photogrammetry/Mapping with Pix4D**

*Angad Singh, Pix4D, Inc.*

This tutorial will be aimed at geospatial professionals, and will include the following concepts:

- Introduction to Photogrammetry concepts used by Pix4D
- Image Capture, camera types, and platforms used
- Cloud vs desktop processing
- Georeferencing
- Verifying accuracy
- Creating a project
- Live demonstration of interface
- Outputs workflow
- Reviewing the quality report



**Instructor:** Angad Singh.

Angad is a trainer and customer support representative for Pix4D based in San Francisco. He has experience with GIS and Remote Sensing applications, specific to crop yield analysis and using UAS systems for high resolution mapping. At Pix4D, he is responsible for teaching the Pix4D User Workshops as well as Private Trainings.



<http://propertydrone.org>

## **Keynote 1:**

### **The Use of Drones in Commercial Property Inspection**

*Charles Mondello, Property Drone Consortium*

This talk will provide an overview of “The Use of Drones in Commercial Property Inspection”. The briefing will cover data capture through dissemination. It will discuss current challenges in operations of sUAS and look to a future in which drones become a common place tool in the commercial property sector. Insurance and roofing will be used as key market examples for the overview.



#### **Speaker Bio**

As the current President of the Property Drone Consortium, Charles Mondello is active with unmanned aerial system research and strategy for property inspections with emphasis on regulatory and standards development. He was recently appointed as a member of the Federal Aviation Administration’s (FAA) Drone Advisory Committee Subcommittee. Mondello is currently a chief industry strategist at EagleView Technologies, where he shapes client requirements into corporate initiatives.

Mondello’s career encompasses multiple leadership roles including IBM, Federal Government, Litton, Kodak and his recent prior position as EVP of corporate development at Pictometry. He served on the inaugural National Geospatial Advisory Committee as a commercial member. Mondello has a Master’s and Bachelor’s degree in Imaging Science from Rochester Institute of Technology and holds multiple patents in remote sensing/photogrammetry in oblique and real-time data processing.



venture **creations**

<https://www.rit.edu/research/incubator>

## **Keynote 2: Venture Creations and UAS Entrepreneurship**

*Richard Notargiacomo, RIT Venture Creations*

This talk will discuss RIT's Venture Creations Technology Business Incubator, including: who we serve, how we work with client companies, and the results we have achieved. My goal is to create awareness of Venture Creations in the hope that anyone in our served groups who has thoughts of starting a company will see us as their "first stop" in that exploration.



### **Speaker Bio**

Rich Notargiacomo is the Director of RIT's Venture Creations Technology Business Incubator and Adjunct Professor at RIT's E. Philip Saunders College of Business. At Venture Creations, Rich works with entrepreneurs and business teams to help them develop their businesses. He is also working to drive increased deal flow from RIT student and faculty led businesses as well as continuing to serve other companies that are aligned with RIT's scholarly and research

missions and objectives.

Prior to joining RIT, Rich was President of Innovation Focus Rochester, LLC, an executive coaching and consulting firm that helped companies grow through innovation and new products. Before that he was at Eastman Kodak Company where he had roles in a variety of business/product units as well as a broad range of functional areas.

He is a past Chairman and President of the Product Development and Management Association, a professional organization for people engaged in innovation and new product development. He is also a Member of the Board of Governors of the Hillside Family of Agencies. Rich is a certified New Product Development Professional (NPDP). He holds an MBA with a concentration in marketing from the University of Rochester's Simon School and a BS in Chemical Engineering from Rensselaer Polytechnic Institute.



## **UAS Operations Within Controlled Airspace**

***Brian Blazey, Federal Aviation Administration, Airspace and Procedures Specialist***

The Air Traffic Organization branch of the FAA manages all of the controlled airspace within the US. Depending on the purpose of each flight, the UAS pilot/operator must notify, or obtain approval from, Air Traffic Control when operating within controlled airspace. We will look at the different classes of airspace and follow the application process for an airspace authorization or waiver.



## **The Role of Flight Standards District Offices in UAS Safety**

***Robert Lacourse, Federal Aviation Administration, Aviation Safety Inspector***

The talk will be centered around FSDO role in UAS safety. To include types/levels of enforcement actions.



## **NASA UAS Traffic Management (UTM) for Wildland Fire Air Domain Awareness**

***Ed Freeborn, CTO, Unmanned Experts***

***Verne Laclair, Vertex Geospatial***

Unmanned aircraft systems (UAS) and small UAS (SUAS) technology hold great promise for facilitating the management of wildfires on forest lands. However, technology is only a small part of the problem of integrating UAS into fireground operations. Significant concerns must be addressed about the coordination of air assets in the high-risk operational wildland fire airspace environment, which can be remote, complex and uniquely challenging. Wildland firefighting requires the cooperation and coordination of multiple agencies and functions under the Incident Command System (ICS), interagency dispatch, and through airspace coordination. Proper roles and management of UAS as air assets within this framework are currently being defined based on the earlier groundbreaking work of NASA and the U.S. Forest Service (USFS), and more current work to operationalize UAS technology.

This presentation will report on our work under Phase I of a Small Business Innovative Research (SBIR) project with the U.S. Department of Agriculture to apply NASA UAS Traffic Management (UTM) to this problem space.

# R·I·T

## **MX1: A New Multi-modal UAS Payload System with High Accuracy GPS and IMU**

*Timothy Bauch, Rochester Institute of Technology*

Remote sensing is becoming increasingly popular in the UAV market. Research is being conducted across the world using all types of imaging modalities to gather higher resolution data. As sensors have become smaller, and UAV payload capacities have become larger, the ability to create payload combinations of multiple modalities has risen. For many research projects the use of multiple modalities is needed. In remote sensing, the weather conditions and time of collection play a major role in the success of the collected data. This presentation outlines a new multi-modal payload system that allows for simultaneous collection of four different types of imaging modalities; RGB, LWIR, LiDAR and Hyperspectral. By collecting all modalities simultaneously, we can collect data with the same weather conditions and light levels. This also eliminates the need to change gimbals in the field and reduce the wear and tear on the equipment from multiple payload changes.





## **USGS National UAS Project Office: Progress on Radiometric Calibration of UAS Imagery**

***Kelsey Mason, National Unmanned Aircraft Systems Project Office, United States Geological Survey***

The United States Geological Survey (USGS) National Unmanned Aircraft Systems (UAS) Project Office (NUPO) strives to be a leader in safe and efficient UAS operations, applying the most cutting-edge hardware and software available in pursuit of collecting and generating scientifically defensible UAS data and products. This mission has led to a current research effort focusing on radiometric calibration of multispectral UAS data. Currently, for multispectral measurements we employ the MicaSense RedEdge camera. The RedEdge is composed of five 3.6 MP, 12 bit sensors with discrete and narrowband filters imaging in the visible to near infrared (VNIR) between 475 and 860 nm. Thus far, the radiometric corrections we have tested include: vignette correction, exposure compensation, irradiance compensation (utilizing data from the MicaSense Downwelling Light Sensor), sun angle correction and empirical line calibration (ELC). Preliminary results show differences of up to 0.95 between normalized difference vegetation index (NDVI) maps generated from non-corrected imagery and NDVI maps generated from vignette corrected, exposure compensated and ELC imagery. Other correction methods in development include dark current correction and correction for inconsistencies in light transmission between the five filters. Longer-term, we hope to obtain radiometric calibration targets that are more Lambertian, as well as more fieldwork friendly (lighter, waterproof and easily cleanable) and to continue working with the Rochester Institute of Technology (RIT) Digital Imaging and Remote Sensing (DIRS) Laboratory, the USGS-EROS Data Center and the USGS Spectroscopy Lab, to develop streamlined methods and software for radiometric correction of UAS imagery.



## **Small Unmanned Aerial Systems (sUAS) in Support of Advancements in Remote Sensing Data Quality**

***Katie Corcoran, Oak Ridge National Laboratory***

***Devin White, Oak Ridge National Laboratory***

***Bill Monday, Oak Ridge National Laboratory***

***Melissa Allen, Oak Ridge National Laboratory***

Remote sensing data collected at different times, from different platforms, or using different sensing modalities, have long challenged analysts aiming to make the most of their data. The more similar multiple data collections are in terms of their temporal, spatial, and spectral attributes, the more straightforward their comparison. Where these variables differ between collections, there exists aggregate error that diminishes the value of information extracted from them. In response, researchers in the Geographic Information Science and Technology group at ORNL are currently engaged in the development of automated registration and remote sensing imagery enhancement tools aimed at minimizing the effects of these problematic variables. In doing so, we aim to broaden the accessibility of disparate data, to ultimately increase the applicability of existing analytical algorithms. Currently, our team is focused on three efforts: image orthorectification and registration, identifying and accounting for atmospheric and scene anomalies, and image-derived point cloud generation. In cooperation with research partners at the Rochester Institute of Technology and the University of Arkansas, our teams collect sUAS data to help generate a library of data needed to develop and test these growing capabilities. Compared to manned campaigns, sUAS offers a rapid mobilization of hardware for data acquisition at low cost. As sUAS technologies continue to improve, the quality of data approaches that of more traditional remote sensing data sets. sUAS presents many of the challenges faced with manned aircraft, making it an appropriate substitute for non-sUAS platforms. This presentation will cover experimental designs and results to date.

# R·I·T

## **A Novel Calibration Technique for Images Captured by Unmanned Aerial Systems (UAS)**

*Baabak Mamaghani, Rochester Institute of Technology  
Carl Salvaggio, Rochester Institute of Technology*

Recent advances in technology have made small Unmanned Aerial Systems (sUAS) a hot commodity for defense, commercial and even research applications. These applications include, but are not limited to: target detection, search & rescue, crop/field surveying, disaster management and reconnaissance. Regardless of the application, the images that are collected from these systems need to be calibrated correctly. This is done to ensure that when the images are analyzed, the results are accurate. For this reason, we have developed a novel technique for calibrating images that have been captured from a sUAS. Our sUAS is outfitted with an integrated light sensor (Micasense RedEdge) to measure down-welling radiance, while white and black calibration panels are placed in the flight path of the sUAS. By finding the closest match of down-welling radiance in each image to the images with calibration panels, each image can be calibrated with higher accuracy than previous methods such as the Empirical Line Method. In addition to calibrating the images, shadows are located within the images to analyze the affect on NDVI. Conclusions will be presented on whether or not this method of calibration and shadow detection produce more accurate known reflectance values.



## **Drone-based Sensing for Solid Waste Facilities**

***Brent Bartlett, BeamIO***

Current techniques for measurement of landfill surface conditions are a labor intensive process. Ground based sampling and inspection is typically achieved by a field technician walking the landfill surface within a grid while collecting/recording data with hand-held devices. These techniques produce low sampling density, increased chance for missing problem locations, and user generated errors associated with data transcription. Additionally, field technicians are exposed to environmental hazards consisting of heat or cold stress, sunburn, wind chill, poisonous plants, or potential insect-borne diseases (West Nile virus, Lyme disease, etc.). BeamIO's Tiledriver is a cloud-enabled processing platform capable of utilizing automated drone-mounted sensor technologies that address these challenges by significantly reducing costs, enabling more in-depth analysis, increasing sample density, and improving reporting and safety. Partnered with Barton & Loguidice, D.P.C. (B&L), BeamIO has shown strong correlation between drone measurements with those made by traditional handheld systems. Map based visualizations will be presented showing fugitive gas emissions and as-built wellhead locations. Enabled by the Tiledriver platform, these techniques allow facilities to quickly and more accurately identify landfill gas collection infrastructure that deviates from engineering plans or is in need of repair.

Syracuse City



School District

## **UAS in Secondary Education**

***Edward Levine, Syracuse City School District***

Around the country UAS are being used in schools to support STEM and arts programs. In Syracuse, NY UAS are the focus of a 4-year program for Syracuse City School District students. The UAS Technology instructor from Syracuse City Schools will be sharing what UAS looks like in a CTE high school classroom as well as how programs across the country are using UAS to support STEM.

# R·I·T

## **Quadrotor Controller Development via Model Based Design**

*Daniel Kaputa, Rochester Institute of Technology*

Low cost compute platforms such as the Raspberry PI and advances in 3D printing have changed the technical landscape for hobbyists, inventors, and engineers alike. These new tools provide the designer with a low cost method for performing rapid prototyping of embedded systems, however the daunting task of algorithm development still lurks in the shadows. Traditionally, programs are hand-coded in languages such as C or Python and there is an inherent disconnect between the deployed code and the high level system model. This disconnect between domains increases the likelihood of bugs creeping into the code. Model based design provides a way to accelerate algorithm development and minimize coding errors by placing the system model at the center of the development process from requirements through design, implementation, and testing. We present the development of a model based quadrotor controller created via the Simulink Coder product from the Mathworks.

# R·I·T

## **Microsystems Technology Inertial Sensors for Unmanned Aerial Vehicles**

*Liam Herlihy, Rochester Institute of Technology*

*Sergey Lyshevski, Rochester Institute of Technology*

We examine inertial measurement units (IMUs) and inertial navigation systems (INSs) for unmanned aerial vehicles (UAVs). Robust information acquisition, fusion and management are accomplished by means of post-processing on multi-degree-of-freedom IMU and INS digital outputs. The examined IMUs and INSs comprise cyber and physical modules and subsystems. The considered advanced solid-state and MEMS-technology networked sensor arrays enable distributed intelligence. Information acquiring, acquisition, fusion, management and sharing may be accomplished by means of an intelligent cloud. Cloud level capabilities at the IMU- and INS-node level enable key performance metrics and capabilities of multi-level hierarchical distributed information management architectures. Distributed post-processing using microcontroller or flight management processor is accomplished. Our developments and findings are demonstrated and substantiated by performing consistent low-fidelity technology evaluation and assessment in laboratory environment. Overall functionality, adaptiveness and situation awareness are improved ensuring conformity with command, control, intelligence, surveillance, and target acquisition tasks.

**Notes:**